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Pico Satellite Solar Cell Testbed (PSSC Testbed)

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Abstract

The PSSC Testbed flight experiment is designed to obtain space environment degradation data for advanced solar cells. The purpose of the first flight (ISS orbit) is to develop and operationally test the picosatellite and associated ground station. Subsequent flights will be in a GEO transfer orbit, which will provide accelerated radiation degradation data for missions to geosynchronous orbit.

The two U.S. solar cell manufacturers, Spectrolab and Emcore, are starting production of a new generation of High Efficiency Solar Cells on a two to three year cycle. These new cells are committed to fly on major DoD space assets as soon as they are placed in production. Presently, with the accelerated introduction of new solar cell technology into the production, the first time that these new technology solar cells actually are flown are on a major satellite program. This has in the past resulted in unexpected interactions with the space environment, which caused either failure of the solar arrays or significant degradation of performance limiting ultimate useful life on orbit. Ground testing of new solar cell technology consists of sequential exposure of the solar cells to the various elements of the space environment. These elements include radiation (electrons, protons, gamma rays), thermal cycling, atomic oxygen (LEO orbits only), ultraviolet light & visible light illumination, and micrometeoroids. Thus the combined effects of these individual components of the space environment are not tested for and determined prior to flight on a major DoD spacecraft.

To address this problem there is a need for responsive space flight capability to test new solar cell technology within the time cycle for introduction of the new technology and before the launch of new satellites with the new solar cell technology. The Aerospace Corporation has developed a Pico Satellite spacecraft bus, which includes a solar power system with the capability to characterize new solar cells. This picosat could be the starting point for the development of a responsive space vehicle that would provide the capability of obtaining actual space environment exposure of new solar cell technology in a time frame that is in sync with the new generation solar cell's introduction cycle. Once this vehicle is flown successfully and demonstrates its capability, the spacecraft bus can be used as a standard testbed for any type of future solar cells with minimum modification.

PSSC Testbed Description

The PSSC Testbed flight experiment is designed to provide the United States Air Force with space flight data that will be used to validate performance models for new multijunction solar cells. The total size of the PSSC Testbed is 5 inches by 5 inches by 10 inches. The satellite will have four Emcore Very High Efficiency solar cells mounted on each of the two sides and four Spectrolab XTJ solar cells mounted on each of two sides, which have dimensions of 5 inches, by 10 inches. Figure 1 shows the qualification test unit of the PSSC Testbed body with the Emcore Solar Cells mounted on it.

Figure 1. PSSC Testbed Qualification Test Assembly

The PSSC Testbed satellite will include a flight computer, radio for communications, battery ring bus converter & charger board, solar ring bus converter board and GPS receiver. There are three electronics bays available in the 5 inch by 5 inch by 10 inch Picosatellite. The payload electronics package described above **will not** use all three of the available bays in the picosatellite. Thus, the PSSC Testbed could become a standard Picosatellite bus for a wide variety of space flight experiments with a minimal cost, including space components other than solar cells. Figure 2

provides a photograph of a typical Picosatellite Electronics Module, which would occupy one of the three bays available in the PSSC class of picosatellite.

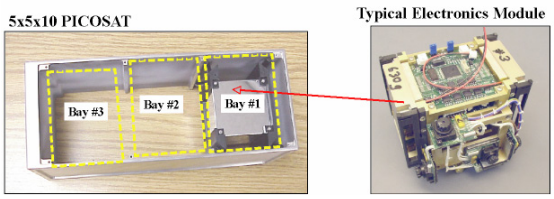

Figure 2. Electronics Payload Layout for PSSC Testbed

The PSSC Testbed will use a ring bus architecture which has been under development at The Aerospace Corporation.[1-4] The ring bus will allow the solar cells which are the subject of this flight experiment to provide power for the spacecraft and provide a detailed Current Voltage (IV) characteristic of the solar cells. By measuring the IV characteristic of the solar cells the environmental degradation can be as a function of time on orbit can be determined.

PSSC Testbed Experiment Description

The solar cell manufacturing industry has a long history of performing ground based qualification tests on solar cell technology. Presently there is an effort underway to produce a solar cell qualification standard, which is being spearheaded by The Aerospace Corporation, Air Force Space and Missile Center and the Air Force Research Laboratory. One of the items that were identified by this effort is the need for early flight of new technology solar cells before they are flown on a major DoD or NRO space asset. There have been several commercial and military spacecraft that have failed or had the useful life of the spacecraft reduced due to unforeseen interactions between the space environment and the solar arrays.

Prior attempts to obtain space environment exposure data have failed due to the schedule delays in integration and launch process of the host spacecraft. By the time the flight experiment was finally launched the solar cell technology being tested already had several years of use on orbit and the technology was no longer in production. To resolve this problem the Pico Satellite Solar Cell Testbed is designed as a special purpose Pico Satellite whose mission is to obtain solar cell performance data on orbit. As a Pico Satellite there are multiple missions on which it may fly. Ultimately, with a Pico Satellite launch capability on multiple EELV missions, a PSSC Testbed could be manifested and launched on demand thus further reducing the time between initial production of new solar cell technology and the receipt of orbital performance data.

The initial flight of a PSSC Testbed will be Low Earth Orbit (LEO) even though a Geosynchronous Transfer Orbit (GTO) would provide accelerated radiation exposure as shown in Figure 3. Missions in a GTO would allow the accumulation of several years of equivalent radiation exposure as compared to a Geosynchronous Earth Orbit (GEO) in a very short period of time.

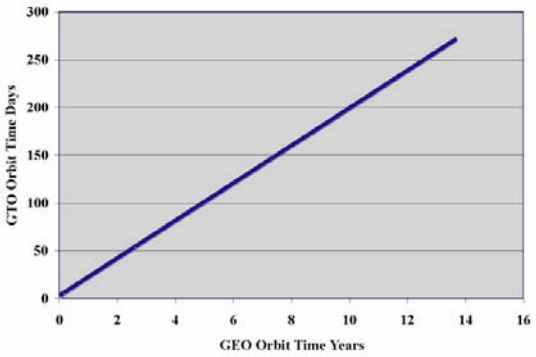

Figure 3. Comparison of Total Dose Radiation as a function of Time for GTO Vs. GEO Orbits

Rational for LEO Orbit for First Flight

The rational for using a LEO orbit for the first mission is to reduce risk and ensure mission success. The operational procedures for carrying out a long duration Picosatellite mission have not been demonstrated prior to the planned first mission. The use of LEO for the first PSSC Testbed mission will allow the researchers to have more opportunities to communicate with the PSSC Testbed on a daily basis. PSSC Testbed radio link to the ground has a limited range. Due to this limited range the communications link for a GTO mission could only be closed when the perigee of the GTO orbit were to pass over the ground station.

The PSSC Testbed will be equipped with a GPS receiver and a beaconing capability to enable accurate tracking of the vehicle and prediction of its orbital parameters. This data will be integral in scheduling contact times with the PSSC Testbed. This is a new capability for Picosatellites, which will enable the use of orbits other than LEO for future missions. It is desirable to demonstrate this capability prior to relying on it for communications

with the PSSC Testbed, as would be the case if the GTO orbit were selected for the first mission.

This information will greatly reduce the risk that a major program takes when new technology solar cells are baselined in the design of a new spacecraft without prior flight data.

Conclusions

With the successful completion of demonstration of this new technology demonstration, the Air Force and industry can consider the inclusion of requirements for actual space flight data as a requirement for space qualification of new technology solar cells. This requirement would eliminate unpleasant surprises for major programs due to lack of knowledge regarding actual space flight performance of new technology solar cells. Ultimately the Air Force could sponsor the fabrication and acceptance testing of several PSSC Testbeds that could be pressed into service as soon as a solar cell manufacturer has a new generation of advanced solar cells in the space flight qualification process.

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